EXPLANATION OF PLATE XII.

Fig. 1. Homopus signatus.
Fig. 2. Kinixys erosa.
Fig. 3. Geoemyda spinosa.
Fig. 4. Geoemyda grandis.
Fig. 5. Emmenia Grayi.
Fig. 6. Emys Fraseri.
Fig. 7. Chrysemys picta.
Fig. 8. Trachemys Holbrookii.
Fig. 9. Pseudemys concinna.
Fig. 10. Bellia crassicollis.
Fig. 11. Damonia macrocephala.
Fig. 12. Damonia Reevesii.
Fig. 13. Platysternon peguense.
Fig. 14. Cuora amboinensis.

XLIII.—*On Spontaneous Division in the Echinodermata and other Radiata.* By Dr. C. F. Lütken*.

It is only in a few specimens of *Ophiothela isidicola*, sp. n.† (from Formosa), that I have found the six arms equal or nearly so: in most individuals of moderate size the three arms of one side are larger than those of the opposite side; and in this respect we find all possible intermediate stages, from specimens with three arms well developed and three scarcely perceptible, to others in which the difference is insignificant. Moreover we find nearly as many specimens having only three arms and the corresponding half of the disk (as if they had been cut with a knife into two equal parts) as of completely developed individuals with six equal arms. There is no doubt that a division has taken place, at least in the case of those which have only three arms, or three large and three small ones, and that the halves produced by this division have the power of replacing the missing half both of the disk and arms. It is only with regard to the minority which are furnished with six equal arms, and in which the two halves of the disk are equally developed, that there can be any doubt; for although the greater part of the individuals of this species may be destined to undergo division, we must not conclude from this that all are so.

Whether the division is repeated several times in this Ophiurid I cannot decide with certainty; but the series of specimens

* Translated and slightly abridged by W. S. Dallas, F.L.S., from a paper entitled "Ophiuridarum novarum vel minus cognitarum descriptiones nonnullæ," published in the Oversigt over det K. Dansk. Vid. Selsk. Förhandl. 1872, pp. 108–158, French summary, pp. 30–54.

† The Latin characters of the new species will be given at the conclusion of this paper.

at my command gives the impression that if the act is not renewed it generally occurs at an early age, and that the lost parts sprout forth as the general growth goes on. Hence the larger the specimens the nearer they approach the normal state (six equal arms, &c.), and the smaller they are (down to a certain limit) the more they approach the divided form with three arms. This rule, however, is by no means without exceptions. Sometimes also the division takes place unequally, so that we meet with specimens with four large and two small arms, or with four small and two large arms; but these cases are rare.

In the case before us the phenomenon would certainly seem to be capable of another interpretation—namely, that these Ophiurids quit the larval state as half individuals, that is to say with three arms (exceptionally four or two) and half (one-third or two-thirds) of the disk, and that the parts deficient are gradually developed; but this interpretation would be immediately rejected as absurd. They might rather, originally, have the whole disk and three arms, so that the new arms might grow in the intervals between the old ones; but although we sometimes meet with six-armed starfishes (*Linckia*) with three short arms and three longer ones alternating with the former, which would seem to support this hypothesis, this mode of development has not been observed in any Asterid or Ophiurid*.

There is yet another question—namely, whether this division is entirely voluntary (*i. e.* a natural spontaneous division) or involuntary (*i. e.* the consequence of exterior violence, of a special lesion so frequent that very few individuals can escape it). The faculty of regeneration is certainly great among the Ophiurids. The disk of an *Ophiura* deprived of all its arms might undoubtedly, under favourable circumstances, regenerate them all; and it is probable that an injury which at the same time removed a small portion of the disk, would be reparable in the same way; at least, I have met with Ophiurids, *e. g. Ophioderma virescens*, the disk of which bore indisputable traces of a partial regeneration of this kind after an accidental injury; and I should not be surprised if experiments of artificial division were successful in many cases, especially with young Ophiurids. It would not, however, be right to conclude from this that the phenomenon described in *Ophiothela*

* In connexion with this, *Ophiacantha anomala* and *O. vivipara* are of interest as Ophiurids with more than five arms (six to eight) which originate with all their arms. It is only in some Asterids, in which the number of arms is very great, that new arms continue during growth to sprout forth between the old ones. To this we shall recur hereafter.

isidicola was simply the result of an accidental natural injury. The regularity with which it is manifested proves sufficiently that this is not the case, but that we have to do with *a true spontaneous natural division, the object of which is multiplication*. The specimens that we possess of the other species of *Ophiothela* are not numerous; but I have ascertained that the four species with which I am best acquainted present an analogous peculiarity; for together with regular individuals with six (exceptionally five) arms, we find others in which the three (or rarely two) pairs of radial plates on one side of the disk are smaller than the others, and the corresponding arms only developed in the same proportion: in the Japanese species the four very small specimens at my disposal were all in this unsymmetrical state of regeneration; in the other species it was comparatively rarer. I believe, however, that this character is sufficiently general to allow us to reckon spontaneous division among the generic characters of *Ophiothela*.

As has already been mentioned by Steenstrup*, Sars†, and myself ‡, the same phenomenon is observed in other small six-armed Ophiurids, especially those of the genus *Ophiactis*, which, like the *Ophiothelæ*, live upon corals and sponges; but I have never found any trace of it in the species of that genus which have normally five arms, whilst, as far as I can judge, it may be observed in all the species with six arms. As a supplement to the brief remarks which I have published upon this subject in connexion with *Ophiactis Mülleri*, *Krebsii*, and *virescens*, I will here communicate the observations which I have made more recently. From a sponge from the Red Sea I extracted 16 specimens of *Ophiactis Savignyi*. Most of them (of average size, with a disk 2–3 millims. in diameter) are regularly furnished with six arms, which present no striking difference in length. In some of them, indeed, two or three arms on one side are shorter than the three or four others; but the difference is so slight that it would hardly be remarked in other Ophiurids, and it might be supposed that these shorter arms had been broken and sprouted afresh. (One specimen has seven arms, one of which is distinctly shorter than the rest.) But it is very clearly seen that a division has taken place in the four larger and smaller specimens. In the smallest of all (with a disk a little more than 1 millim. in diameter) one half of the disk and the three corresponding arms are en-

* Forhandl. ved de Skand. Naturforsk. syvende Möde i Christiania (1857), p. 230.

† Bidrag til Kundskab. om Middelhavets Littoralfauna, i. p. 97.

‡ Additamenta ad historiam Ophiuridarum, ii. pp. 127, 129, and 146, tab. 4. fig. 5*d*, iii. p. 38.

tirely deficient, but the wound is already closed and cicatrized; a larger specimen has in part regenerated its deficiencies, but the new half of the disk and the new arms are much less developed than the others. This is also the case, although in a somewhat different degree, with the two largest of these four specimens (diameter of disk 3·5–4 millims.; longest arms about 20 millims.); in one the three new arms are half the length and thickness of the others, and in the other they are only 2 millims. long and of proportionate thickness, the new half of the disk presenting a corresponding development. If we may draw any conclusion from this little series of observations, it would be that the division occurs twice in this species—first, in very small individuals, and then in those which are adult or nearly so.

All the specimens of *Ophiactis sexradia*, Gr. (*O. Reinhardti*, m.), that I have examined have six arms, and in general, especially in the large specimens, there is no striking difference between the arms; it is only in some of the small ones that one of the groups of arms is in course of regeneration. Such is also the case in one of the two small specimens of *Ophiactis virens*, Sars, from the Mediterranean, which I have had the opportunity of seeing. Sars says of this species that all his 23 specimens had six arms, and that in nearly half of them "the three arms situated on one side were much shorter and thinner than the others, and evidently regenerated after a loss or division." With regard to *O. virescens* of the west coast of America, Mr. Verrill* states that he has always found six arms, but that many young individuals had only three, the three on one side being entirely deficient or very small, as if in course of regeneration. Out of 13 specimens I found 12 with six arms, partly unequal; the thirteenth, which is one of the largest, has five equal arms. I have always found *O. Krebsii* with six arms: a great number of the small individuals show the regeneration; the large specimens always have the arms and the radii of the disk equally developed. Of *O. Müller*i most of the smaller examples have six unequal arms; but there is a certain number with five equal arms; and most of the adult specimens seem to be in the latter condition.

Except in the above-mentioned genera I only know of a single instance of heteractinism among the Ophiurids—namely, in the young individuals of a certain group of species of the genus *Ophiocoma* (*O. pumila*, *Valenciæ*). This case is particularly interesting, because it is positively confined to the young individuals, which alone present unequally developed

* Notes on Radiata, No. 2, p. 205.

groups of arms and have more than five arms*. The transformation of the young six-armed individuals into individuals with five arms evidently requires a previous division. They can only lose the sixth arm by regenerating, after the last division, only one or two arms instead of two or three.

It would be very incorrect to conclude from the constant occurrence of heteractinism (and of division if our interpretation of heteractinism is correct) in this tolerably long series of six-armed *Ophiothelæ*, *Ophiactines*, and *Ophiocomæ*, that the same things occur in the other Ophiurids which have normally more than five arms. These, however, are not numerous as far as I know; for, leaving out of consideration the young *Asterophyton* with seven arms described by me (which is as puzzling to me as it was thirteen years ago, and which is still known only from a single specimen) and *Asteromorpha Steenstrupii* (in which the six-armed state is probably only an accidental anomaly), we have in this category only two species of *Ophiacantha*, namely *O. anomala*, Sars, with six, and *O. vivipara*, Lgm., with seven to eight arms; and in neither of these has any thing been observed to indicate a division. The necessary condition for spontaneous division would therefore seem to be that the species (at least when young) should have normally more than five (six) arms, although we must not conclude that it exists from this greater number of arms: in one of the above-mentioned groups (*Ophiocoma*) it is evident that the spontaneous division is confined to the young; and it is not improbable that this is the case also with the others; but this does not at present appear with sufficient clearness from the facts, and the solution of this important question must be left to subsequent researches upon living animals. Its importance consists in the fact that if it is answered in the affirmative the laws of reproduction in these Ophiurids would fall under that of *alternation of generations*, the young individuals then representing the agamic generations, and the adults, after division, the sexual ones.

Perfectly similar phenomena are manifested in certain As-

* All the young individuals, however, or those which have not yet acquired the physiognomy, coloration, &c. characteristic of the species, do not present six arms or the heteractinism which is associated with that number. I have already mentioned (Addit. ii. p. 146) that of 12 specimens, 8 had six arms, two or three of which were generally shorter and thinner than the others. Of 21 specimens now at my disposal (1 of *O. Valenciæ* and the rest *O. pumila*) I find that, with one exception, all the individuals below a certain size (4 millims.) have six more or less unequal arms, and all those which measure 5 millims. or more have five arms. The exception is a specimen with six arms rather larger than it should be according to this rule.

terids—namely, in *Asterias problema*, Stp. (*albula*, Stimps.), and *A. tenuispina*, Lamk., and in some forms allied to these two species. In common with the fissiparous Ophiurids they have normally more than five arms; but this furnishes no ground for supposing that other Asterids with six or more than six arms have some tendency to division; indeed we have examples to the contrary in the *Solasteres* with many arms, and in the six-armed *Asterias polaris*, neither of which presents the least traces of this mode of reproduction. What strikes us immediately in looking at a series of *A. tenuispina* and *problema* is, that a great many of them have the arms unequally developed, and that the shorter and weaker arms form on one side a separate group, as if they had been developed after the others, which no doubt is the case. MM. Steenstrup*, Sars†, Häckel‡, and Von Martens§ have already devoted special attention to the former species; but I will, notwithstanding, communicate the result of my own observations. Of 23 specimens 11 (with seven to ten arms) have incontestable traces of a regeneration of three to seven (most frequently four) arms: the smallest of these 11 specimens is $1\frac{1}{4}$ inch in diameter; the largest, if the weaker (younger) side were as much developed as the other, would measure $5\frac{1}{2}$ inches. The smaller the specimens the more clearly in general do we see that a regeneration of this kind (and the previous division?) has taken place: of 15 specimens less than 4 inches in diameter, 9 are in this condition; whilst of 8 which vary in diameter from 4 to 7 inches, there are only 2. In the other 12 specimens (of the 23) the arms are either (approximately) of the same length, or the number of shorter ones does not exceed one or two, and the existence of a single arm shorter than the others indicates nothing more than an accident which is very common in all starfishes, namely that one or more of the arms may have been broken or torn away and regenerated. The series of specimens that I have examined does not indicate that this division and regeneration, perhaps frequently repeated, must result in the number of arms in the larger and more developed individuals being on the average either greater or less than in the young individuals‖.

* Forhandl. ved de Skand. Naturforsk. syvende Möde i Christiania (1857), pp. 229 *et seq.*

† Bidrag til Kundskaben om Middelhavets Littoralfauna, ii. p. 108.

‡ Generelle Morphologie (1866), i. p. 350.

§ Archiv für Naturg. xxx. 1, p. 68.

‖ See also some remarks by M. R. Greeff on the Asterids of the Canaries, and among others *Asterias tenuispina*. He says it is "worthy of remark that on the rocky shore exposed to the action of the breakers, we scarcely meet with any but small and irregular specimens, whilst far from the

What we observe in *Asterias tenuispina* probably occurs also in the allied species, *A. acutispina*, Stimpson* (Japan), *A. microdiscus*, Stimps.† (Bonin islands), and *A. muricata*, Verr. (New Zealand); but the specimens at my command are too few to enable me to assert that spontaneous division takes place in these species; it is, however, very probable. It is the same with *A. atlantica*, Verr. (Bermudas, Brazil), if it differs from *A. tenuispina*. Mr. Verrill mentions one specimen of it with seven large unequal arms, and one with eight arms, four of which were smaller than the others.

Of *Asterias problema* I have examined several hundred specimens obtained from Greenland by Prof. Steenstrup, and noted the characters of about half of them. It is extremely rare to meet with five-armed specimens of this species. Out of 136 I have only found 7 such (or about 1 in 20); their size is very variable (radius = 5–19 millims.): in general the five arms are of the same length, and then it is possible that this number five may be original; less frequently there are two or three a little shorter, probably due either to an irregular division of a six-armed individual forming one with four arms, and another with two arms which has become a five-armed individual by regeneration, or to an individual with three arms having regenerated only two arms instead of three, the third having been aborted. If we carefully examine a specimen which apparently has only five or four arms, we shall frequently find at one of the angles of the arms the germs of two new arms in the form of minute buds; so that the small number of arms is in this case only provisional‡. It is rare, moreover, to find specimens with six or seven arms in which the arms are either equal or approximately equal, without our being able to recognize a fixed law in the slight difference which they present (fig. 1, *e*, p. 330): I have found this only in 12 of the specimens mentioned above; and these equal-armed specimens measured from 5 to 41 millims. in radius. The great majority (fig. 1, *d*, *f*, *i*) are furnished with six arms, three of which, on one side, are shorter and in all respects less developed than the others; and this difference between the two

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shores, in deep water and in sheltered places, we find much larger and more regular specimens."

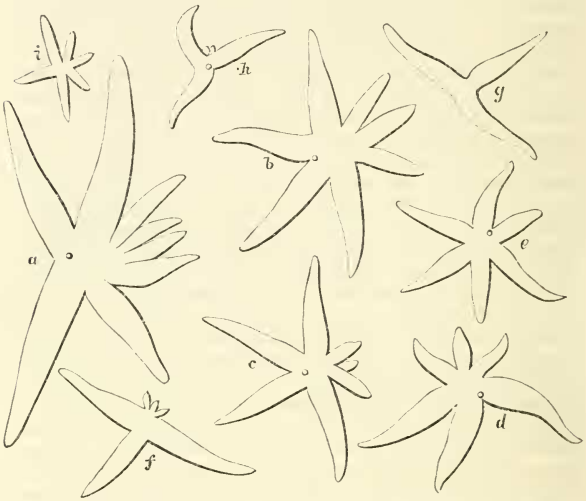
* In 4 specimens belonging to this species, Mr. Stimpson found 5+4, 4+4, and 2+5 arms (Proc. Bost. Soc. Nat. Hist. viii. p. 262).

† Sent under this name by the Smithsonian Institution. I do not find it described in Mr. Stimpson's work mentioned above.

‡ The appearance of five arms arises sometimes from the union of two arms; the double ambulacrum explains this apparent reduction of the arms.

groups of arms occurs in all possible degrees: the smaller group may sometimes scarcely differ from the larger; or it may be reduced to 3 (1, 2) scarcely visible buds (fig. 1, *h*). Of the 3 (or 4) regenerated arms the middle one (or 2) generally appears after the two outer ones. Numbers such as 4+2, or

Fig. 1.



Sketches of 9 individuals of *Asterias problema*, all represented of the natural size. In most the madreporic plate is indicated.

2+4, or 3+2, or 2+3 must be regarded as exceptions, as also 4+3 (fig. 1, *b*, *c*), or 3+4, or 4+4 (fig. 1, *a*), or 4+5, or 5+2, in which the total number of arms exceeds six. Evidently in all cases the smaller group of arms is developed long after the other, and consequently there must have been a period when all these starfishes had only 3 (or exceptionally 2, 4, or 5) arms; in examining a sufficient number of specimens we find several with 3 arms, in which no trace of the deficient arms can be discovered, and among these some (fig. 1, *g*) in which the place where the division probably took place, and where the new arms will be formed, is still open. These specimens with 3 arms (exceptionally with 2) I have found of all sizes, from 3 to 25 millims. or more in radius; moreover, as the specimens

in which one group of arms is less developed present all conditions of size and all possible degrees of development, we must conclude either that the division, supposing it only to occur once, may take place at very different periods in the life of the animals, or else that it is several times repeated, certainly more frequently than in *A. tenuispina*, at least four or five times, perhaps much more frequently. The comparative rarity of the regular individuals with 6 equally developed arms seems to me to furnish a decisive proof of the frequent repetition of the division; but it is only by observations upon the living animals preserved for a long time in aquaria that this question can be settled. It may, perhaps, be supposed that the division ceases when, by the slow growth which accompanies it, the individuals have attained the limit of their development, and acquired the faculty of reproducing in the ordinary manner; but at present this is only an hypothesis. The largest of my specimens (radius 46 millims.) is at any rate far from having attained the point at which all trace of division has disappeared; it has 7 arms, 4 of which (regenerated) are still only 15–28 millims. in length.

If we refuse to admit that these abnormal phenomena, confined, however, within definite limits, may be explained by repeated division and regeneration of the deficient half, it would be necessary to suppose that what occurs is simply an elimination of a certain number of arms effected for some determinate purpose; and the first explanation which would present itself to the mind would be that already indicated by M. Steenstrup—namely, that in this case we have something analogous to the formation of the hectocotyli in the Cephalopoda, a group of arms charged with semen being thrown off to fulfil a special function of reproduction and afterwards regenerated. But there is absolutely nothing in favour of this hypothesis; and it seems to me to have against it the fact that the regeneration of the arms is quite as frequent in the smallest as in the largest specimens. The analogy with the Ophiurida with a supposed spontaneous division, in which this hypothesis would meet with still greater difficulties, is also a powerful motive for rejecting it for the Asterida also*.

* An investigation of the organs of reproduction could not elucidate the phenomena under consideration, unless it be made upon a great number of fresh specimens of all ages and all degrees of development. What is especially necessary to be ascertained is whether *Asterias problema* propagates by ova before the spontaneous division is concluded. I have examined some of my specimens with this question in view, but, as might be expected, without throwing much light upon it. I ascertained that the organs of reproduction were well developed in specimens measuring only 14–16 millims. in radius; on the other hand I found no trace of them

I have found two madreporic plates placed far from each other in the large specimens of *Asterias problema* when the regeneration was so far advanced that the younger group of arms was scarcely behind the older one in development. At the next division, therefore, each half starfish would be furnished with its madreporic plate.

Whether the division always takes place at the same part and in the same line, whether this changes in accordance with definite laws as in the Medusæ, or, finally, whether there is no rule in this matter, I am absolutely unable to say; and I do not think that this question can be cleared up until the species under consideration has been thoroughly investigated in the living state, for which, as it inhabits the north coast of the United States of America, we shall, perhaps, not have long to wait. It is much to be desired that such should be the case, in order that we may know with certainty whether we have to do here merely with a true division, or whether by it some secondary purpose is fulfilled.

Asterias polyplax of New Holland, a species allied to *A. problema*, seems to present the same phenomena; but I have been able to examine only a few specimens of it.

This mode of division is not known with certainty outside the genus *Asterias*, nor even outside certain subdivisions of that genus*. There are, as I have already indicated, a great number of Asterids with multiple arms (*Asterias aster*, *Heliaster*, *Pycnopodia*, *Solaster*, *Acanthaster*, *Labidiaster*, *Luidia*, &c.) which do not present the least trace of this phenomenon. On the other hand there are certain species of *Ophidiaster* and *Linckia* which seem to be subject to another kind of division; but whether it is perfectly natural, or artificial (in the sense of being provoked by some external violence), I cannot decide.

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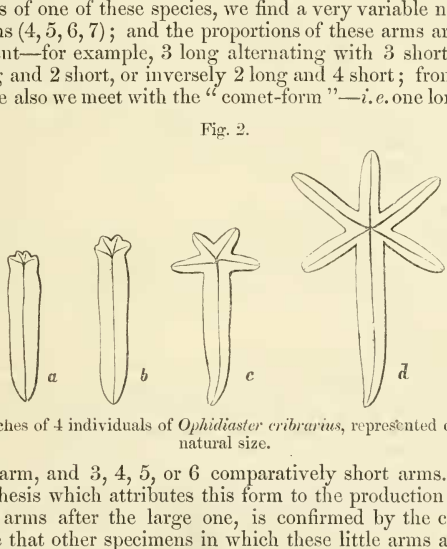
in other specimens of the same or even larger size (15–18 millims.), and even in a large specimen with six equal arms (43 millims. in radius). Perhaps it may depend in part upon the season whether these organs are or are not developed. In specimens of moderate or pretty large size I have generally found the reproductive organs well developed in the older arms, but wanting in the younger ones; nevertheless in two cases (especially in the specimen represented in fig. 1, *a*) they had attained more or less development in the regenerated arms also. It would seem, therefore, that this starfish is *sexual* (*i. e.* furnished with more or less developed sexual organs) long before spontaneous division has terminated; but it does not follow that it is capable of reproduction before that time.

* The Museum possesses a small specimen of *Cribella sanguinolenta* which so much resembles *Asterias problema* that for a moment I took it for the latter; it has three large and three small arms, exactly like *A. problema*. It was brought up from a depth of 290 fathoms, to the west of Hetland.

This singular phenomenon was briefly mentioned by M. Steenstrup; and MM. Häckel and Von Martens subsequently published observations made by them upon it in *Linckia multifora*. I have rarely observed it in that species, although I have examined a great number of specimens; but I have frequently seen it in *Linckia ornithopus* and *Ophidiaster cribrarius*. In both species, as in the fissiparous species of *Asterias* above mentioned, there are in general two madreporic plates; and they are more or less frequently provided with more than five arms. In examining a great quantity of specimens of one of these species, we find a very variable number of arms (4, 5, 6, 7); and the proportions of these arms are very different—for example, 3 long alternating with 3 short ones, 4 long and 2 short, or inversely 2 long and 4 short; from time to time also we meet with the "comet-form"—*i.e.* one long and

Fig. 2.



Sketches of 4 individuals of *Ophidiaster cribrarius*, represented of the natural size.

thick arm, and 3, 4, 5, or 6 comparatively short arms. The hypothesis which attributes this form to the production of the small arms after the large one, is confirmed by the circumstance that other specimens in which these little arms are still less occur in various degrees of development; and, lastly, there are specimens in which they are in the state of mere buds—until we find them with a single arm, either closed at its adoral extremity or still presenting traces of the aperture through which it had communicated with the disk of the animal (see the outlines in fig. 2). From this it seems very clear that the regenerative faculty in these animals is so great that an isolated arm, without any portion of the disk, enjoys the power of regenerating a complete set of arms, with the disk, mouth, &c.; and as we cannot suppose that one arm will be more favoured in this respect than the others, it follows

necessarily that when such a *Linckia* or *Ophidiaster* (with 5 or 6 arms) divides, or, what is the same thing, throws off or loses its arms, it will give origin, under favourable circumstances, to as many new Asterids as it possessed arms, perhaps even to one more if the disk is equally endowed with the faculty of regeneration. I have found in the same species such "comets" of small size and also of considerable dimensions. When the disk and the new arms were still but little developed, there was no madreporic plate; in the contrary case I have always found two, one on each side of the principal arm. If we assume that this division is entirely spontaneous, it would be the first known example of a true natural division being more than binary and producing directly and at once a multiplicity of new individuals—the first true example of the "divisio radialis" of Häckel. That this polymerous divisibility cannot serve to support the singular theory proposed by Duvernoy and taken up by Häckel and other authors, according to which the Asterida and Ophiurida are compound animals, is quite evident.

It may be further remarked that we may also meet with specimens of other Asterids which at the first glance remind us of the comet-shaped *Linckiæ* and *Ophidiastres*: I have myself found examples of *Asterias rubens* of this kind with 1 large arm and 4 small ones in course of sprouting; and Sir John Dalyell* represents several of them which he kept alive for some time; but, so far as I can judge from my own experience, this case is not precisely the same as the preceding, as, in fact, in *A. rubens* the disk remains, and it is by this and not by the single arm, as in *Linckia ornithopus* and *Ophidiaster cribrarius*, that the new arms are regenerated. From this it follows that if an *Asterias rubens* lost all its five arms, none of them could continue to live or regenerate the complete animal; how far the disk alone might be capable of doing so, I do not know. I must add, however, that I have met with some very young specimens of *Asterias problema* in the "comet-form," in which the five or six small arms had the appearance of having been regenerated from the extremity of the only arm which had been detached, and consequently I cannot deny that a polymerous division may also take place in that species†.

* It does not appear with equal clearness from all the figures that the disk continues attached to the oldest arm; and, to judge from the manner in which he expresses himself, the author does not seem to regard this as necessary. Similar regenerated specimens are represented by Forbes and Frédol.

† M. Häckel also has found two specimens of *Asterias tenuispina* with this comet-like form; and at the meeting of naturalists at Christiania in

I do not know that any direct experiments have been made on the divisibility and the faculty of regeneration in the Asterida, although it is easy to prove that they are considerable and general. They are not limited to the long-armed forms, and are manifested in full energy in those which are almost destitute of arms, such as the *Asterinæ*. It is sufficient that out of five or six normal rays two are retained, in order that the remainder shall be readily regenerated; but from this we must not deduce an absolute divisibility. Most of the Asterida can, without difficulty, regenerate a lost fragment of an arm from the surface of rupture itself, whilst in the species of the genus *Asterias* (*Asteracanthion*) the disk alone is endowed with this property, as Steenstrup has indicated. The bifurcate (Y-shaped) arms, sometimes met with in various Asterida*, may be attributed to an injury to these arms, just as the double tails of lizards and the corresponding abnormal formations in certain fishes (*Syngnathi*, *Gymnotini*) are due to a lesion of the tail. The species of *Asterias* sometimes present an arm which is bifurcated in a somewhat different manner, a small branch or secondary arm issuing almost at a right angle from near its extremity, with its ambulacrum opening into that of the principal arm; the origin of this anomaly is also undoubtedly a lesion produced at the point where the lateral branch takes its rise†.

1856, M. Esmark indicated, in connexion with M. Steenstrup's communication, that he had likewise observed in Norwegian Asterida (no doubt in *Asterias rubens*) that an arm without disk had regenerated the deficient parts. M. von Martens describes a comet-like specimen of *Echinaster eridanella* (*fallax*) with six arms.

* For example, *Oreaster gigas* and *Astropecten aurantiacus*. When the bifurcation occurs near the origin of the arm, one might almost suppose that the animal had two mouths. I know examples of this kind in a small *Asterina* from the Mauritius and in *Linckia multifora*. When the two points of union of the ambulacra are confounded in one, we have six arms, two of which are united at the base (a *Scytaster pistornis* in the Museum presents this case). See Linck, 'De Stellis marinis,' tab. xiv. fig. 24, and tab. xl. fig. 70; Seba, 'Thesaurus,' iii. tab. viii. fig. 9; and Treviranus, Zeitschr. für Physiol. iv. p. 124.

† Before quitting this subject I may mention a peculiarity of *Asterias helianthus* and some allied species (of the subgenus *Heliaster*). It has already been said that we must not interpret the heteractinism observed in some Asterida and Ophiurida as due simply to the fact that all the arms proper to the species do not make their appearance originally, but only a portion of them, the deficient portion being subsequently developed; and I added that, if such a case occurred among certain Echinoderms with many arms, it would be much more natural to suppose that the new arms (rays) would originate alternately with the old ones than that they should all spring from a single point. From the fact that we find three long and three short arms alternating with each other in a

That the faculty of regeneration is great in the Crinoids is a well-known fact; but as regards division we know no more about these animals than about the Echinida, in which, indeed, it could only occur in the Clypeastridæ (Scutellinæ), which are very flat; for it is possible only when the animal is constructed in such a manner that the deep wound produced by this violent mutilation may cicatrize in a comparatively short time, which also necessarily presupposes that the animal is extremely tenacious of life, and endowed with a strong faculty

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single specimen of a species, *e. g. Linckia ornithopus*, we cannot, of course, draw any conclusion with respect to this. Now, in *Asterias helianthus*, it seems to me to be beyond doubt that the number of arms is originally small, and increases during the growth of the animal; and as this peculiarity, so far as I know, has not hitherto been ascertained in any Echinoderm, I will here state in detail upon what I found my opinion. The circumstance that the arms in the species in question are often of very unequal length, leads one at once to conclude that some of them may be younger than the others; moreover it is frequently the case that some arms (1, 2, or 3 &c.) are so short that the supposition that they have been subsequently intercalated between the others acquires considerable force; lastly, we sometimes meet with an arm of which the extreme smallness and the awkward position (entirely on the ventral surface, in a slightly dilated brachial angle) can leave no doubt that it is relatively much younger than the rest. If we compare a certain number of specimens of different sizes (I have examined fifteen from 2 to 11 inches in diameter) we acquire a general impression that the smaller they are the fewer arms they possess. This rule, however, can only be taken in the most general sense, and not as if the size and the number of arms constituted two completely parallel progressive series; but it is rarely that several arms in a state of growth are united at the same point. The following Table shows that the smallest number of arms (23) occurs in the smallest specimen, and the largest (41), which is nearly double the preceding, in a specimen which is only half adult:—

Number.	Diameter (approximate) in inches.	Number of arms.
1.	2	23
2.	3	27
3.	3	30
4.	$3\frac{1}{2}$	31
5.	$3\frac{1}{2}$	32
6.	$4\frac{1}{2}$	33
7.	5	34
8.	$5\frac{1}{2}$	31
9.	$5\frac{1}{2}$	38
10.	$5\frac{1}{2}$	41
11.	6	36
12.	$6\frac{1}{2}$	33
13.	$8\frac{1}{2}$	39
14.	9	33
15.	11	38

From No. 1 to No. 7 the augmentation in the number of the arms goes

of regeneration; but these are not the only conditions of division. It is especially easy in flat animals or in those which are slender and elongated; when the animal is equally developed in the three dimensions, the softness and contractility of the body must be greater. Another condition is that the various sections of the body must not differ too much as regards their importance to the whole; but recent observations, showing that even the head and fore part of the body of the Chætopod Annelides may be regenerated in many cases*, indicate that this condition is not one of the most difficult to fulfil.

[To be continued.]

BIBLIOGRAPHICAL NOTICE.

Jottings during the Cruise of H.M.S. Curaçoa among the South-Sea Islands in 1865. By Julius L. Brenchley, M.A., F.R.G.S. With numerous Illustrations and Natural History Notices. Roy. 8vo, pp. 487, pls. 50. Longmans, London: 1873.

There can be hardly any lover of natural history who has not longed to visit the islands of the Pacific, and none who has not envied the good fortune of Banks, Solander, and the two Forsters—voyagers to whom nearly each plant and animal they saw was new, while they were conscious of its novelty. That golden age is, indeed, rapidly passing away; but the present generation need not sigh in vain for worlds to explore. There are still hundreds of islands, not to say clusters of islands, every one a world in itself, untrodden by any white foot save that of the missionary or the whaler; and it needs no saying that neither the fisher of men nor the fisher of

parallel with that of the diameter; but from the time when the latter has acquired a certain magnitude, we do not see so clearly that there is a connexion between the two quantities. Individuality is manifested by one individual being provided earlier than another with the greater part of its arms, or by its growing more slowly, but devoting its growth to the formation of new arms.

I have at my disposal only three specimens of *A. microbrachia*, of which the diameter varies from 3 to 5 inches, whilst the number of arms at the same time increases from 32 to 38. In four specimens of *A. Kubinjyi* measuring from $1\frac{3}{4}$ to 6 inches, the number of arms varies only from 21 to 24, and there is no parallelism between the number and the diameter; of *A. Cummingii* I only possess a single specimen ($7\frac{1}{4}$ inches, 41 arms). In *A.* (*Pycnopodia*) *helianthoides* also it seems that new arms spring between the old ones.

* See Kinberg, "Om Regeneration af hufvudet och de främre segmenterna hos en Annulat" (Öfvers. Vetensk. Akad. Förhandl. 1867), and Ehlers, 'Die Neubildung des Kopfes und des vorderen Körpertheils bei polychäten Anneliden' (1869).